MIT January Operational Internship Experience 2011

Danielle DeLatte
Adam Furhmann
Manal Habib
Cecily Joujon-Roche
Nnaemeka Opara
Sabrina Gonzalez Pasterski
Christina Powell
Andrew Wimmer

Agenda

- Background and Introduction
- Systems Engineering
- NASA Organization
- Workforce Core Values
- Human Factors
- Safety
- Lean Engineering
- NASA Now
- Press, Media, and Outreach
- Future of Spaceflight

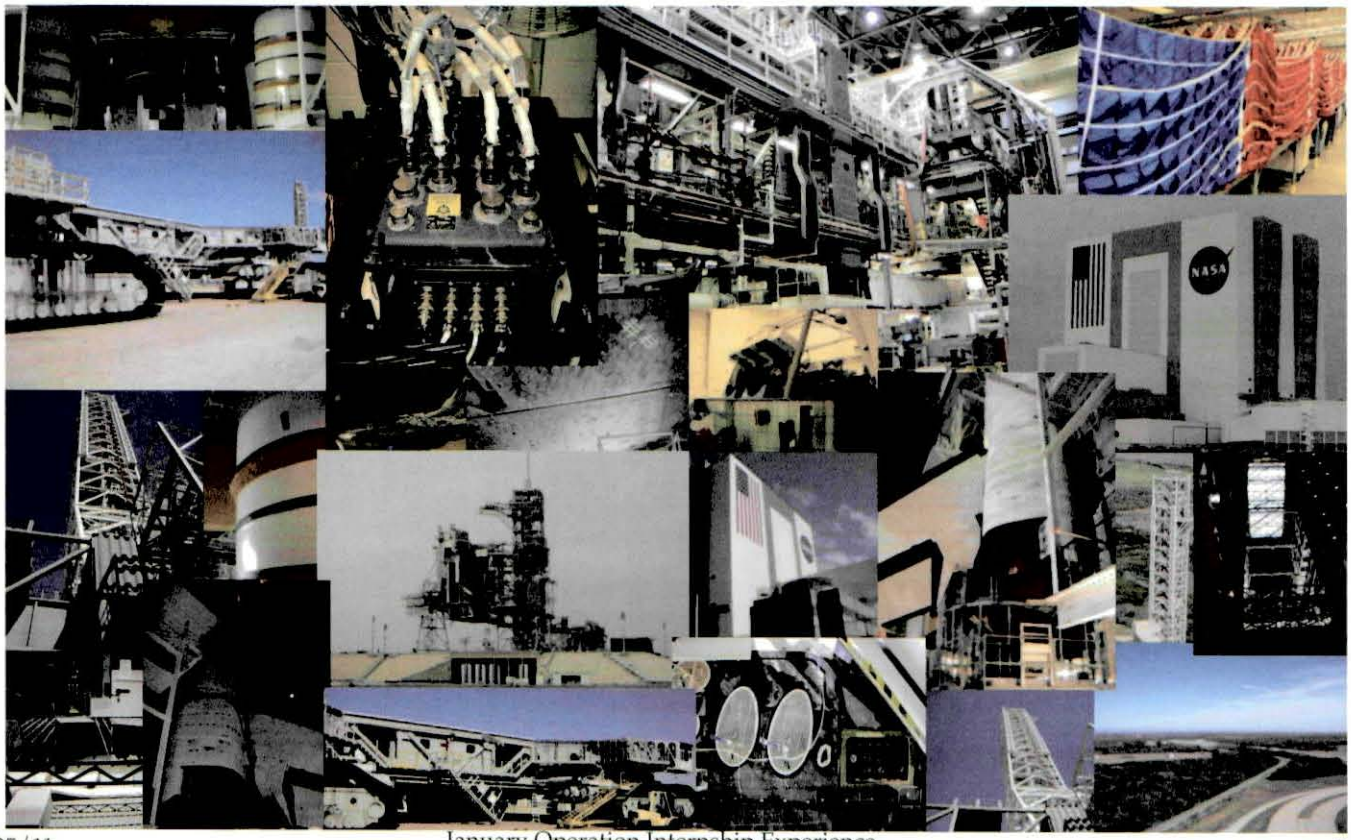
JOIE Program

- 3 week program at KSC
- Allows students to study
  - Operational aspects of spaceflight
  - How design affects operations
  - Systems engineering in practice
- Organized by the Massachusetts Space Grant Consortium, NASA, and ESMD

The Team

- 7 MIT aerospace engineers, 1 Olin College mechanical engineer
- 4 seniors, 3 juniors, 1 freshman
- Previous internship experiences include JPL, JSC, SpaceX, and Orbital Sciences
- Interest in human factors, design, lean engineering, materials, propulsion, controls and analysis

Our Experiences



CDIO

SYSTEMS ENGINEERING

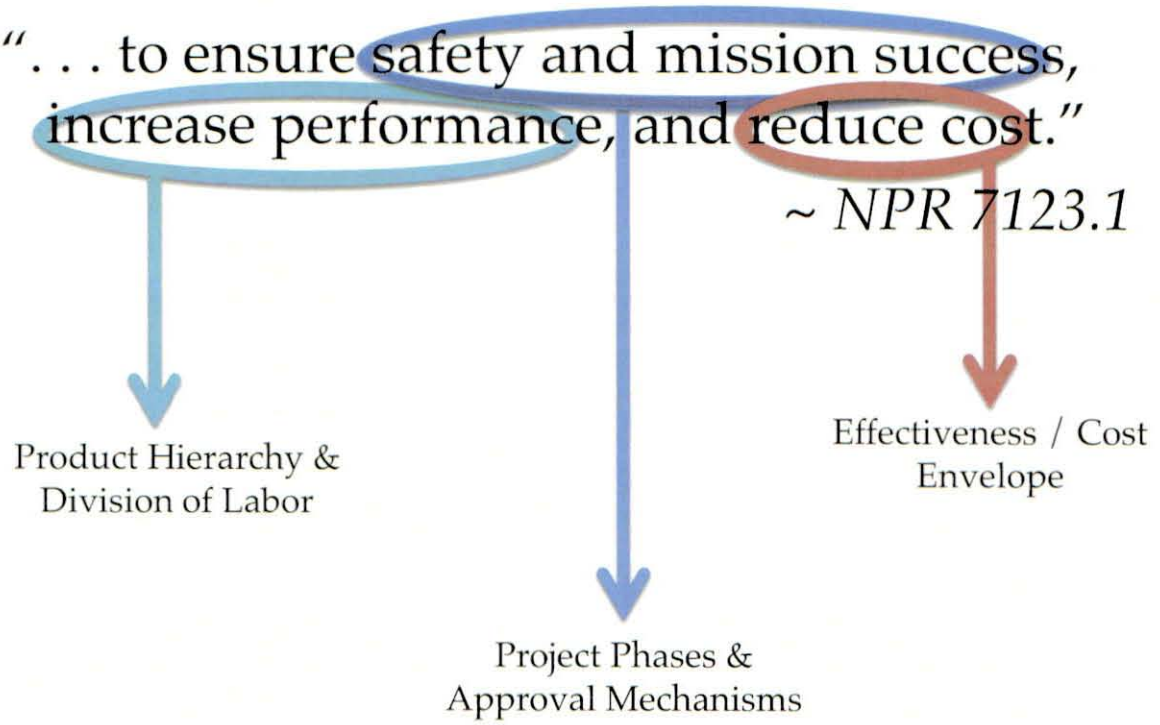
Systems Engineering

- Big Picture Approach
  - Integration of diverse systems
  - Optimization through trade-offs
- Iterative
  - Multiple rounds of development and review

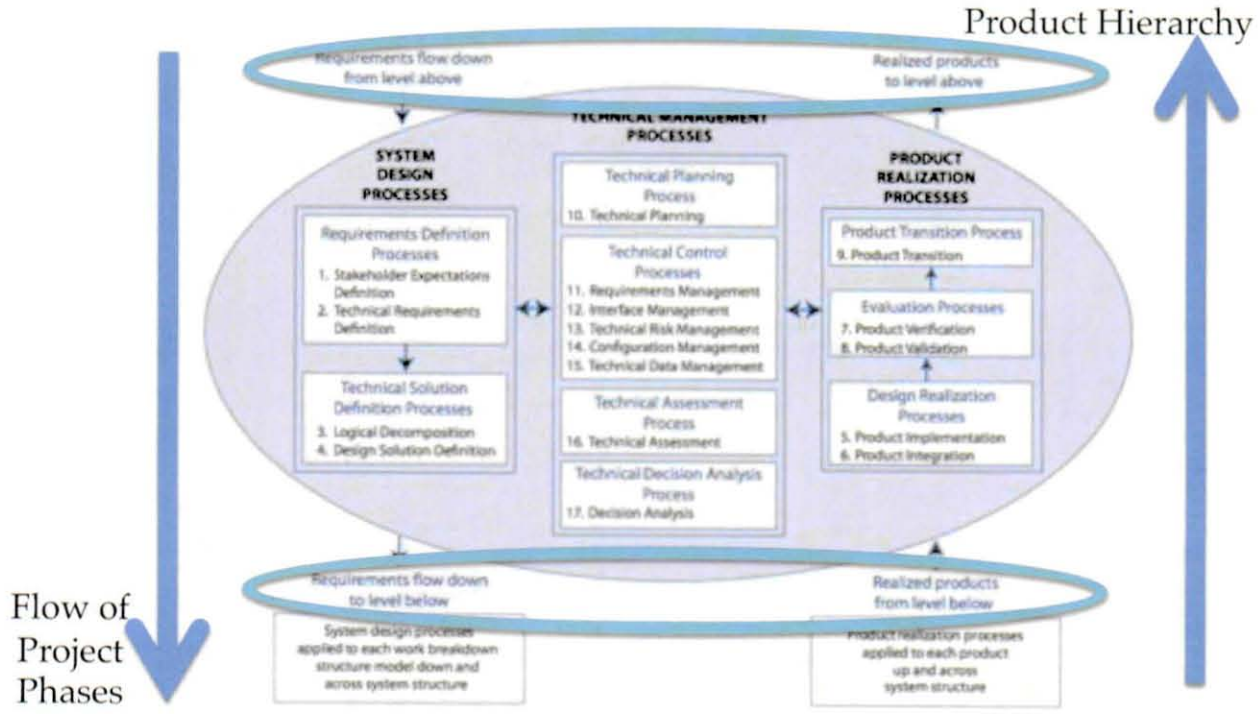
Purpose

"... to ensure safety and mission success, increase performance, and reduce cost."

~ *NPR 7123.1*

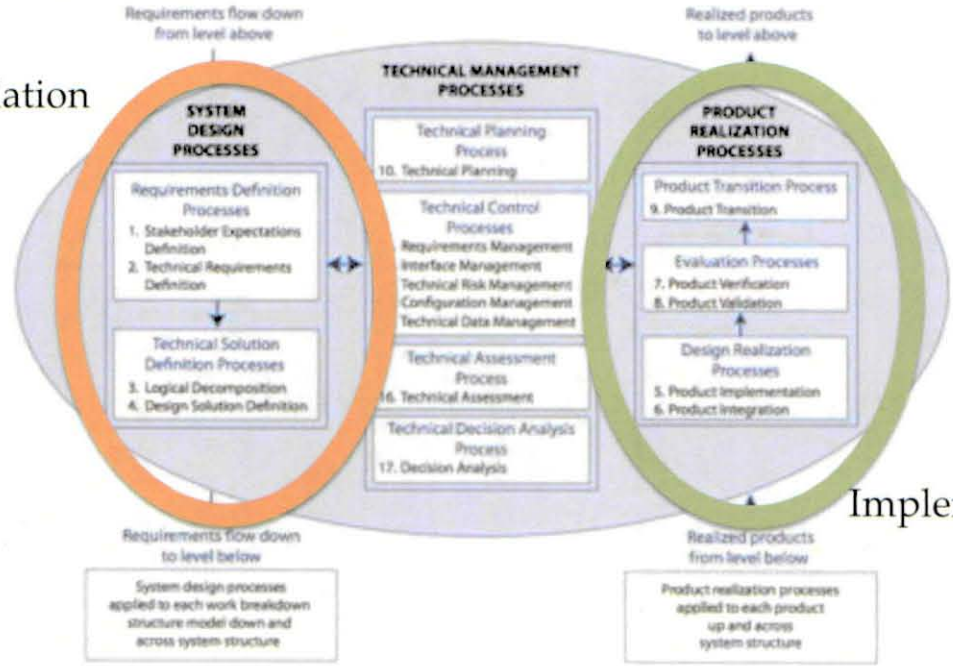


Method: SE Engine



Method: SE Engine

Formulation



Implementation

Formulation

Constellation

- Phase A: Concept & Technology Development
  - Fire & Rescue working with Orion capsule designers
- Phase B: Preliminary Design & Technology Completion
  - Orion capsule mock-ups
  - Constellation Mobile Launcher

Implementation

Shuttle Operations

- Phase C: Final Design & Fabrication
  - Manufacturing of Shuttle tiles
- Phase D: System Assembly, Integration & Test, Launch
  - Preparing Atlantis in OPF
- Phase E: Operations & Sustainment
  - ET stringer repairs
- Phase F: Closeout
  - USA Logistics team

Project Control

Logistics: Resources and Schedule

- Changes over a project's life-cycle
  - Manufacturers
  - Product demand
- Integration
  - Verification of product
  - Validation of system

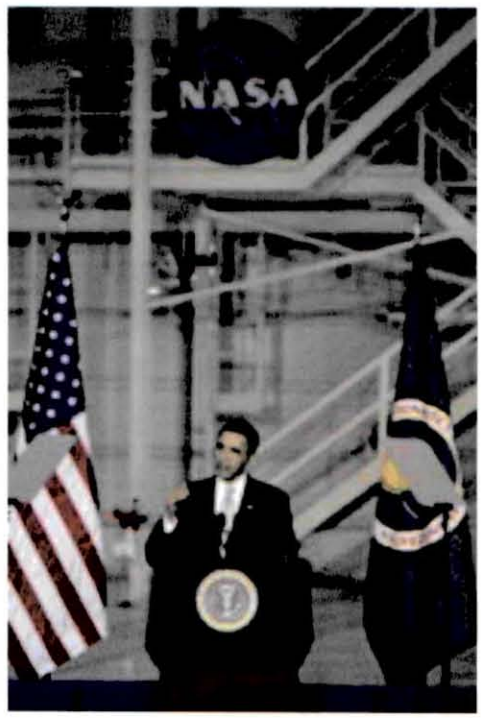
Observations

- Within each system, designs must be balanced and forward-looking
  - Practicality & safety
  - Saving space vs. maintenance
- Integration of systems facilitated by required interactions between teams
  - Agreements between KSC and other centers
  - Chain of command for different tasks

CONTRACTORS

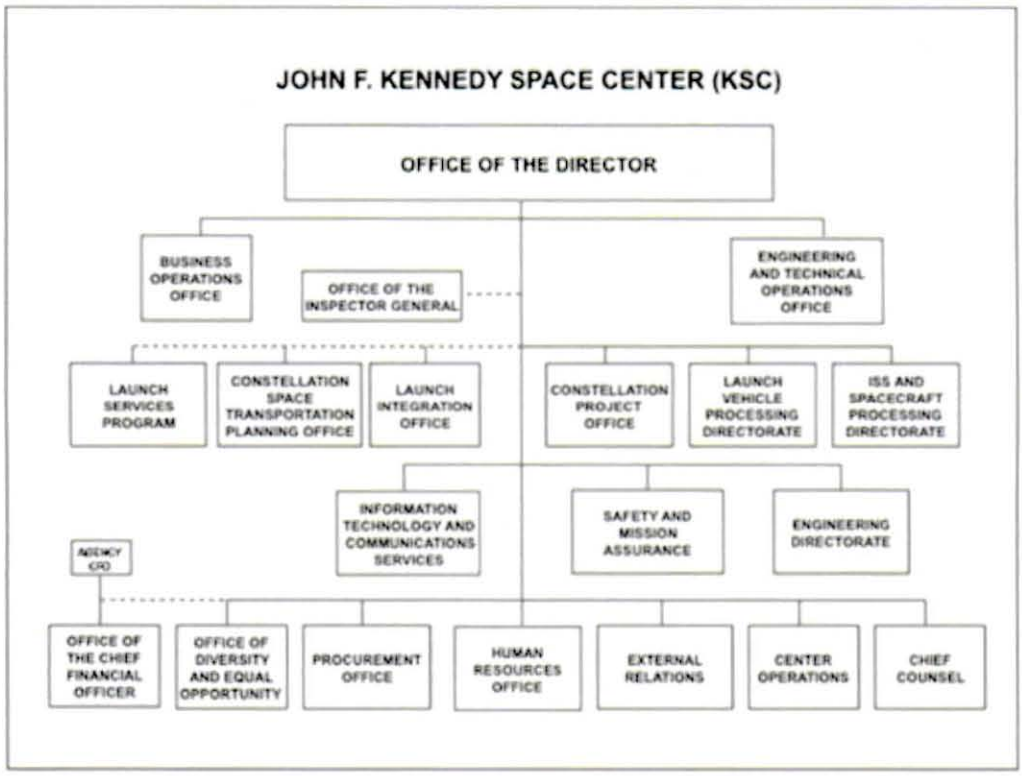
NASA Organization

- Bureaucracy
  - Constellation Cancelled
  - Continuing Resolution
- Procedures
  - Documentation
  - Work Approval Process



Credit: CBC News

KSC Organizational Chart



Credit: www.nasa.gov

KSC Contractors

Contractor	Role
Analex	Expendable Launch Vehicle (ELV) Integrated Support.
ASRC Aerospace	Arctic Slope Research Corporation (ASRC) Aerospace provides research and engineering services and technical support to KSC.
Boeing	Supports payload processing for the Space Station, Space Shuttle, Expendable Launch Vehicles, and other payload programs.
EG&G Technical Services	Services for the operation and management of complex government installations, and military bases.
Pratt & Whitney Rocketdyne	Powers the Space Shuttle and supplies boosters for Delta II, Atlas V & Delta IV.
Science Applications International Corporation (SAIC)	Innovative applications of technology and expertise.
United Space Alliance (USA)	Prime contractor for NASA's Space Shuttle Program, responsible for the day-to-day operation and management of the U.S. Space Shuttle fleet.
Space Gateway Support (SGS)	Delivers fire and rescue support services for both the Kennedy Space Center and Cape Canaveral Air Force Station

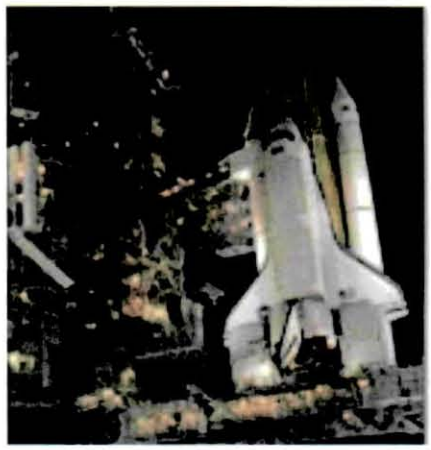
Credit: www.nasa.gov

United Space Alliance

- Established in 1995 by Boeing and Lockheed Martin
- Sought to reduce Space Shuttle program contractors into one primary contractor
- Space Program Operations Contract (SPOC) in 2006
- Over 70% of repairs and spares for the shuttle fleet go through USA
- NASA Shuttle Logistics Depot

USA®

United Space Alliance



Credit: www.nasa.gov

ASRC Aerospace

Credit: www.nasa.gov

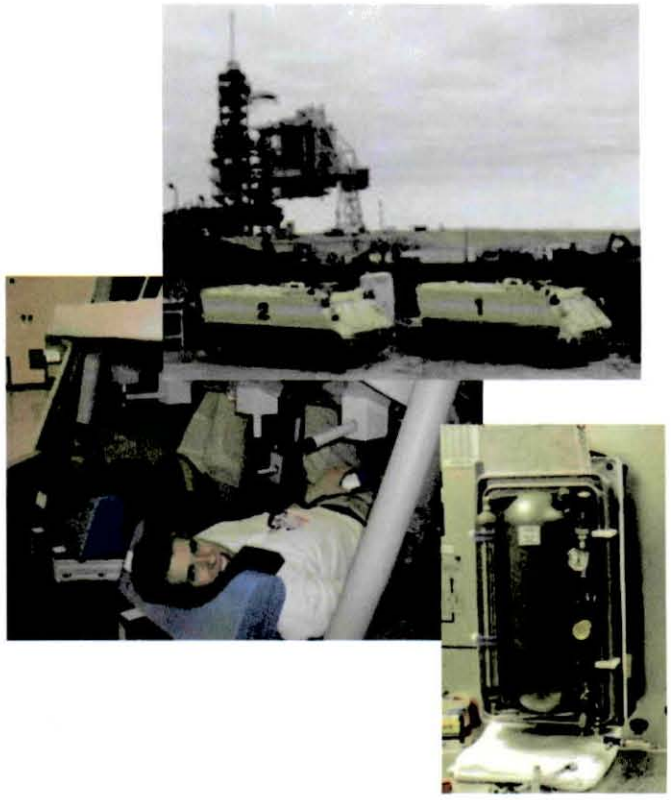
- Vehicle Motion Simulator
- Umbilical Testing
- Cryogenics

- Launch Equipment Test Facility (LETF)
- Quality Assurance
- Rapid Prototyping

Credit: www.nasa.gov

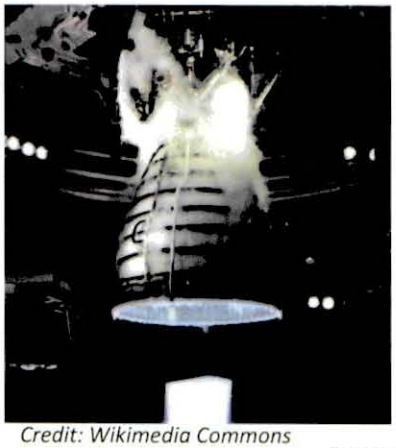
Space Gateway Support

- Shuttle Program
  - Pad rescue for shuttle
  - M113 armored personnel carriers
- Constellation
  - Orion capsule configuration for rescue
  - Liquid air SCBAs
  - Train Air Force Pararescue

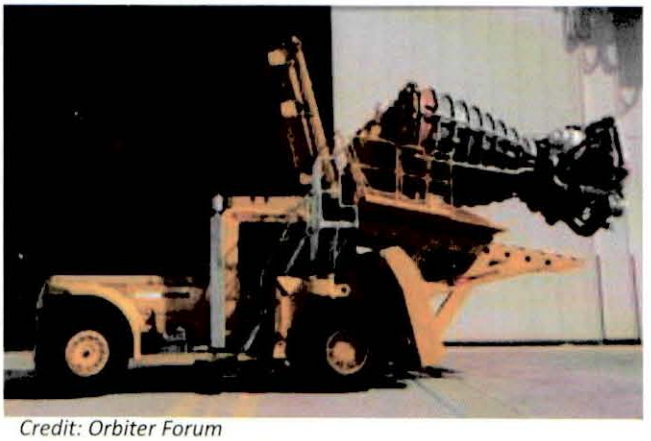


Pratt & Whitney Rocketdyne

- Space Shuttle Main Engine (SSME) Processing
- SSMEs designed in the late 1970s



Credit: Wikimedia Commons



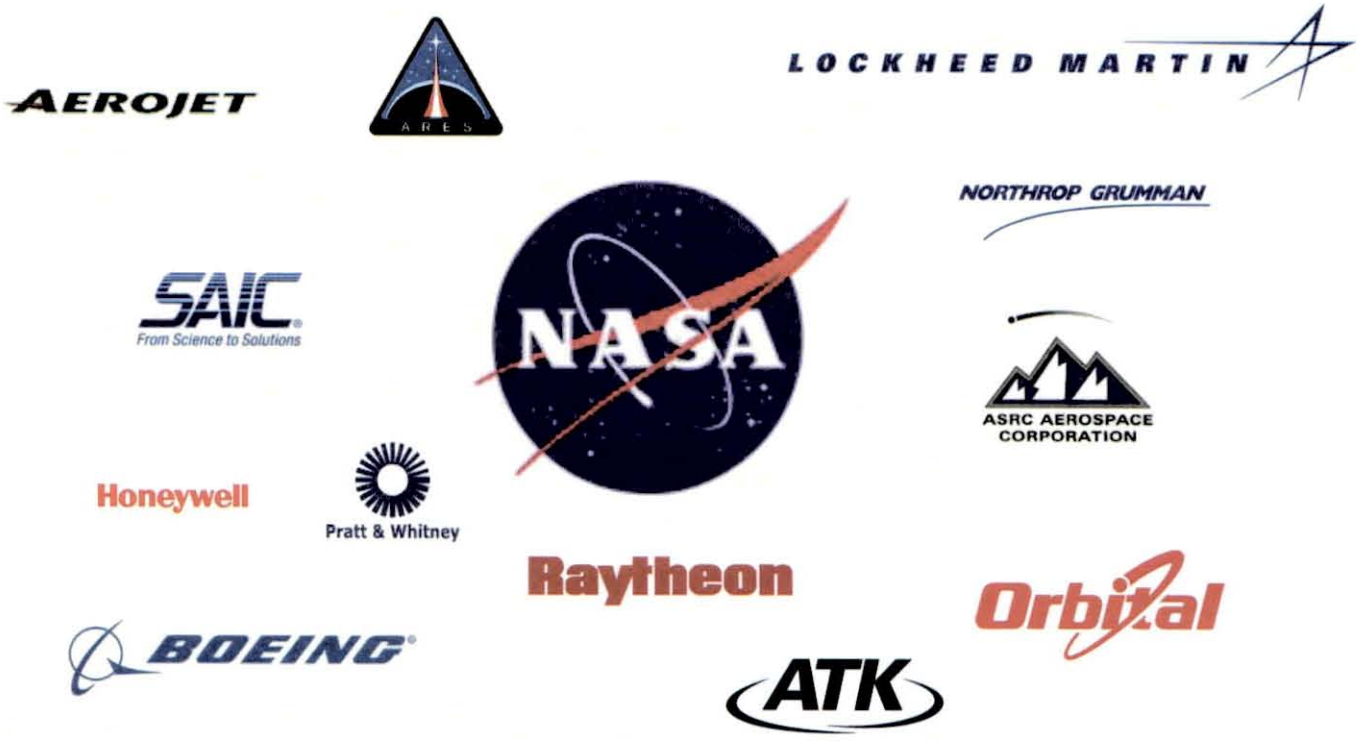
Credit: Orbiter Forum

SAIC

- Provides engineering expertise in
  - Systems engineering
  - Logistics
  - Integration
  - Operation
- Focuses on
  - Expendable launch vehicles
  - Consulting for Constellation program

SAIC
From Science to Solutions

NASA-Contractor Interaction

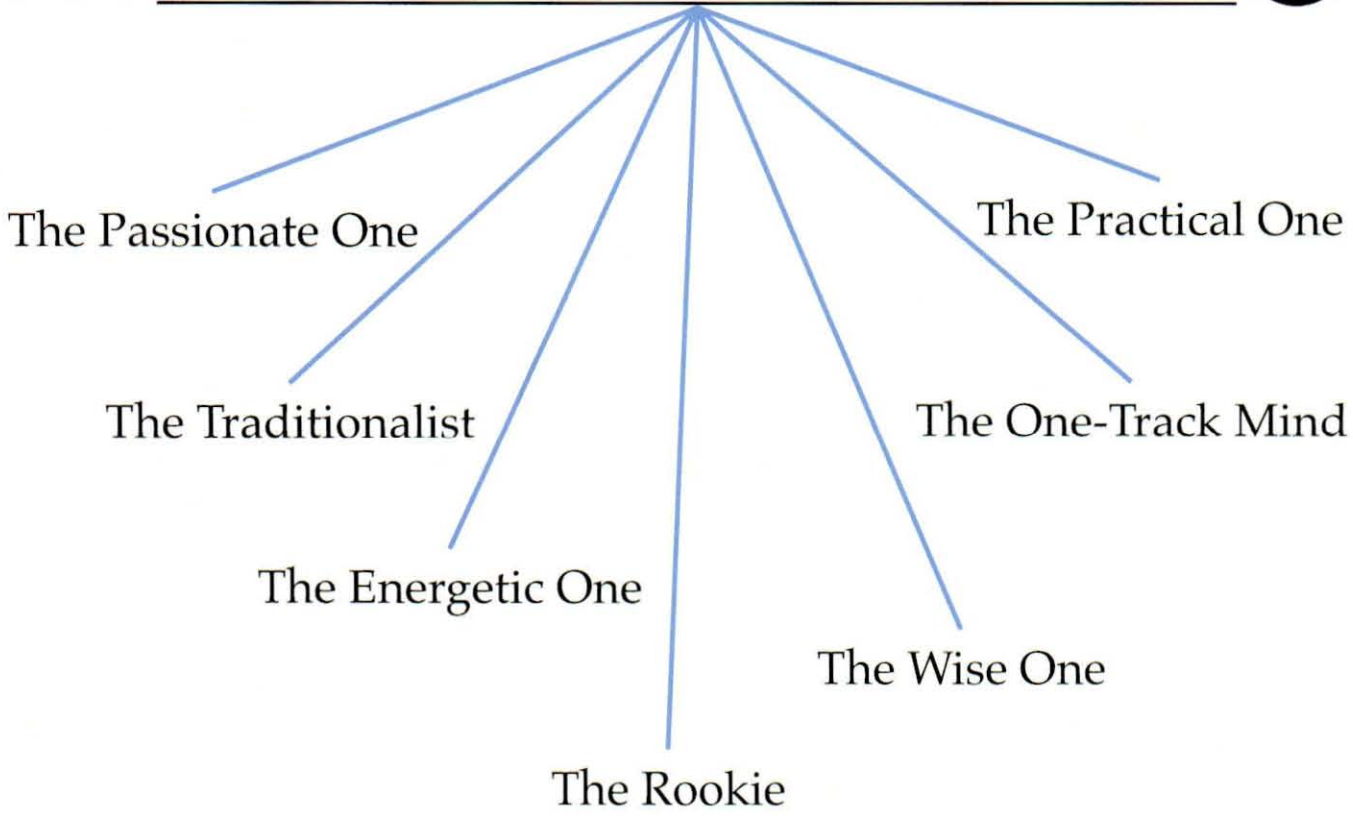


PEOPLE & CULTURE

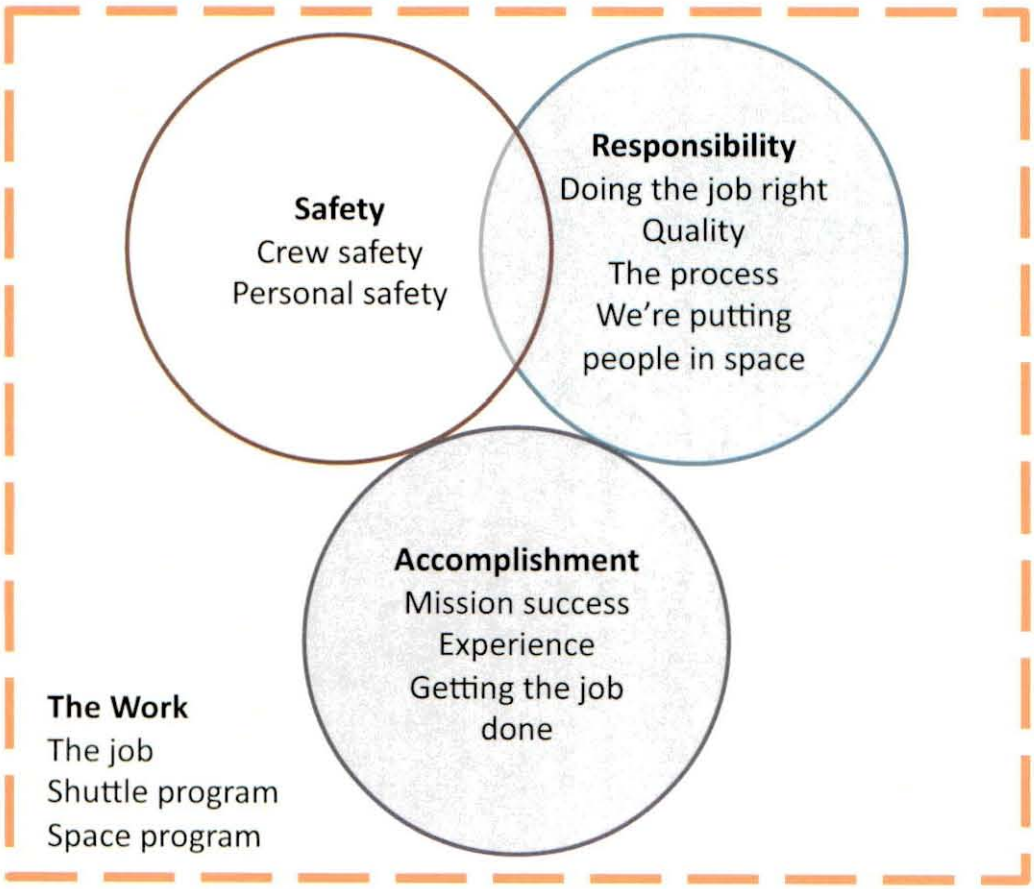
Systems and People

- Constraints and interests for a design have all been set by people
- People working together form as important a group as the technical portions
- Workforce, culture, and values are parts of that system

Types of People



Values


Safety
Crew safety
Personal safety
Responsibility
Doing the job right
Quality
The process
We're putting people in space
Accomplishment
Mission success
Experience
Getting the job done
The Work
The job
Shuttle program
Space program

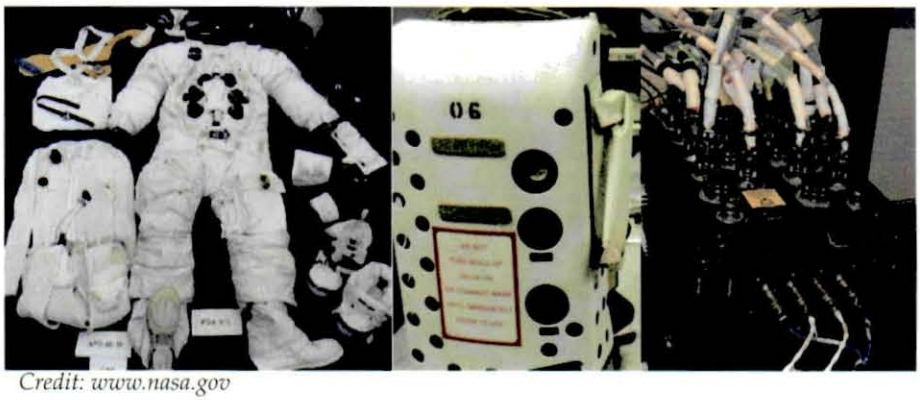
HUMAN FACTORS

Human Factors

Human Factors

- Human factors design rules:
  - Safety
  - Ergonomics
  - Work space design
  - Human/robot interaction: supervisory control

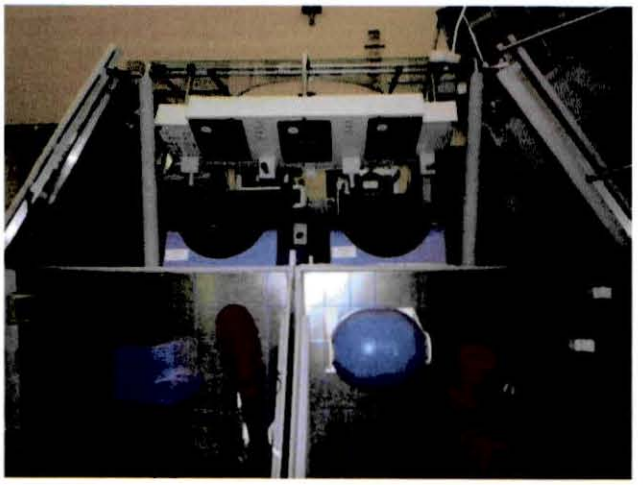
Credit: www.nasa.gov



Credit: www.nasa.gov

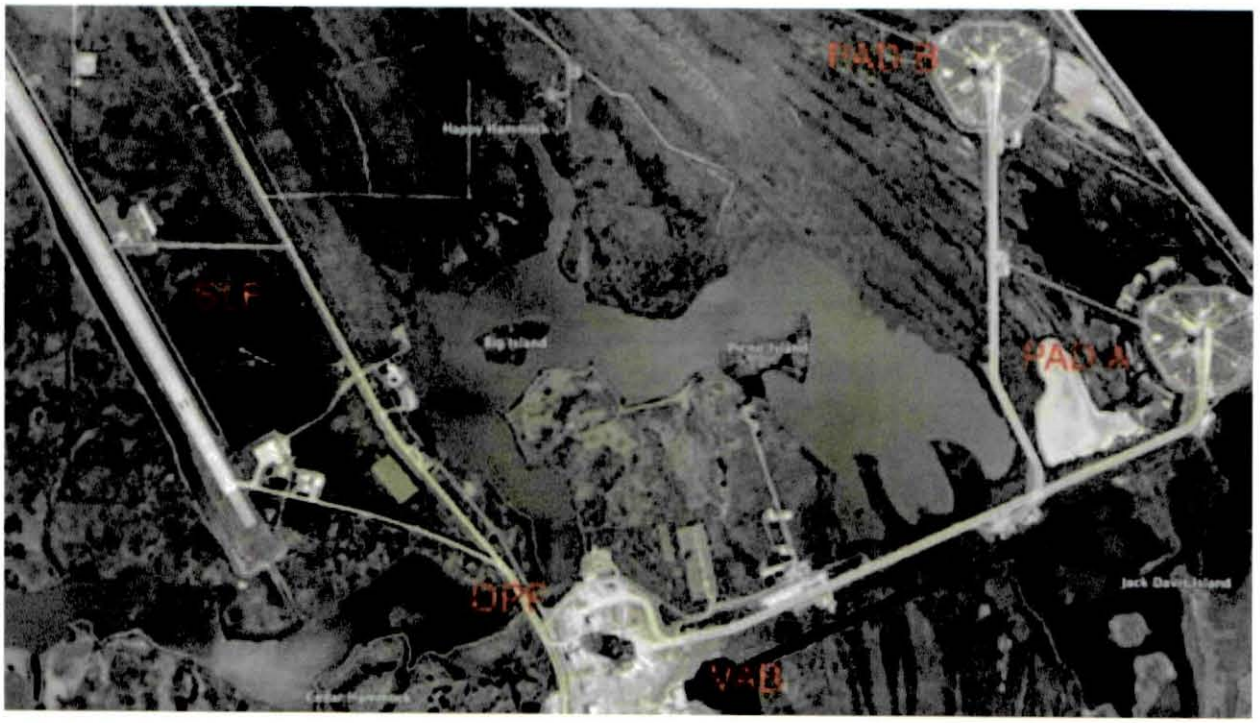
Human Factors: ORION

- Visual access
- Reach
- Work space
- Technical: ground system to Ares I opening and first stage to upper stage opening



LAYOUT

KSC layout



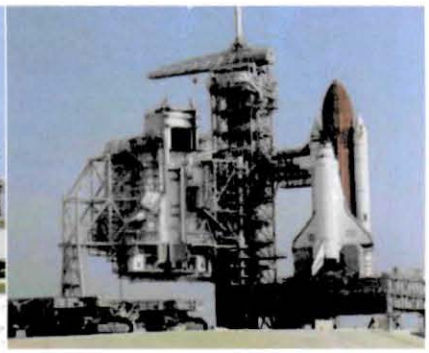
Credit: Google Maps

KSC layout

Operational Processing Facility (OPF)

Vehicle Assembly Facility (VAB)

Mobile Launch Platform (MLP)

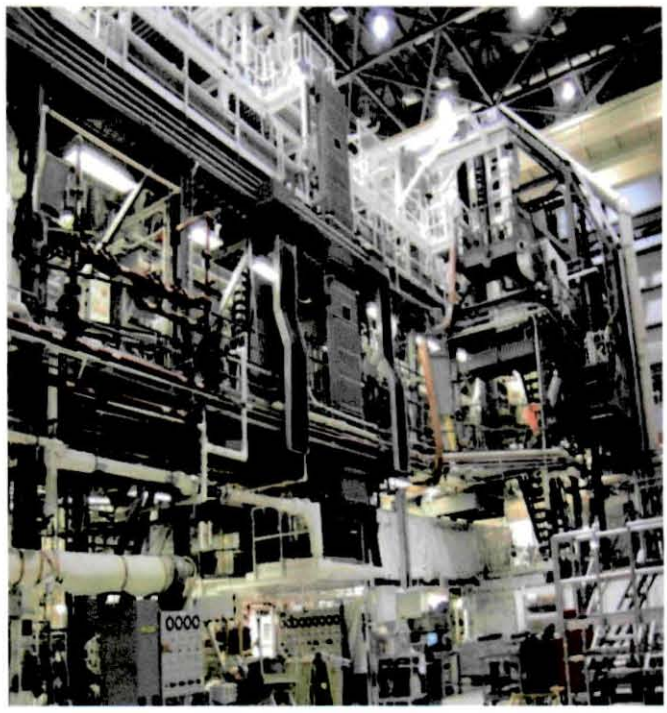


Launch Platform 39-A 39-B

SAFETY

Safety

- Prevention, protection, and handling of hazardous elements
  - Human safety
  - Service equipment
- Communication is key



Human Safety

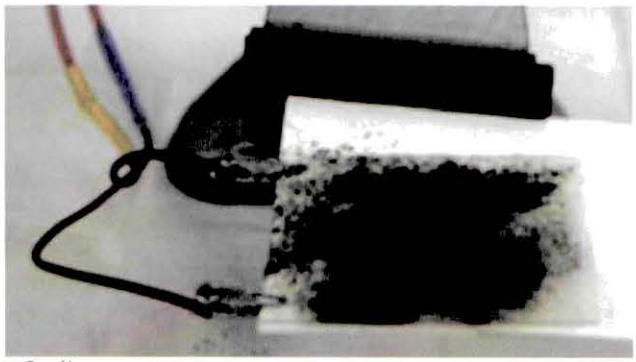
- Astronauts
  - Most important payload
  - Familiarize crew with logistics
- Ground / Crew Support
  - Fire Rescue Team
  - Protective equipment

Service Equipment

- HAZMAT
- End User Friendly
  - Intuitive
  - Redundancy
- Inspection/Testing
- Maintenance

Technology Development

- Safety motivated research
  - Corrosion Lab
  - Electrostatic and Surface Physics Lab
  - Regolith and Granular Lab



Credit: www.nasa.gov

ACCIDENTS

Accidents

- Type and severity range
- Always should be a learning experience
- NASA accidents can be very public and high profile

Credit: Synthstuff.com

Challenger

- 25 years ago today
- Result of known SRB joint O-ring issue that was not properly addressed
- NASA management restructured to encourage engineers to speak up about issues
- Many lessons learned

Credit: http://loftyambitions.wordpress.com/

Columbia

- Known ET issues
- Impact of these issues not properly addressed
- Cultural issues similar to those encountered with Challenger contributed to lack of data about wing damage

Credit: www.nasa.gov

Lessons Learned

- RATS cards
- Modifications to shuttle before each return to flight fixed hardware issues
- Safety is a priority

Lessons Learned

- Accident Investigation Board Recommendations
  - Fixed Technical Issues
  - Patched organizational issues
- Attrition of recommendations to old ways

"Perhaps most striking is the fact that management – including Shuttle Program Mission Management Team, Mission Evaluation Room, and Flight Director and Mission Control – displayed no interest in understanding a problem and its implications."

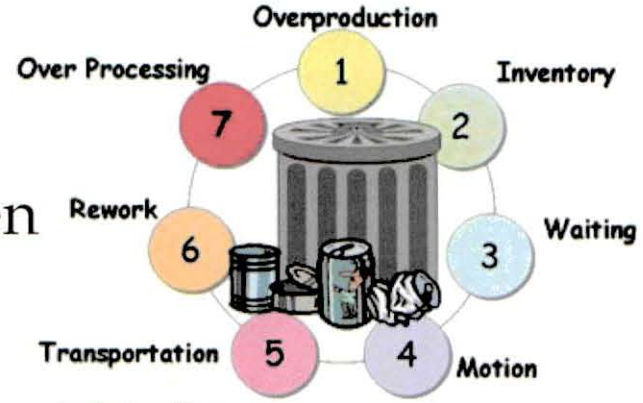
-Columbia Accident Investigation Board

LEAN ENGINEERING

LEAN Engineering

- Reduced Costs
- More Added Value
- Manufacturing Driven
- Reduced Waste
  - 7 Types:

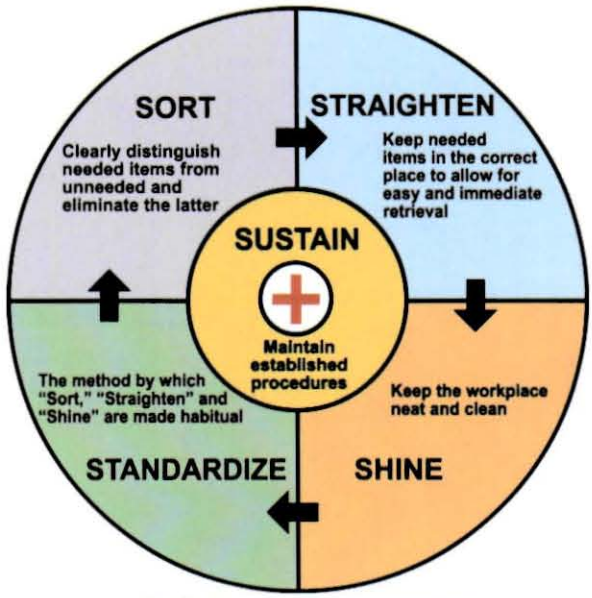
Over production, inventory, waiting, motion, transportation, rework, over processing



Credit: http://lsspmp.com

Places we saw LEAN

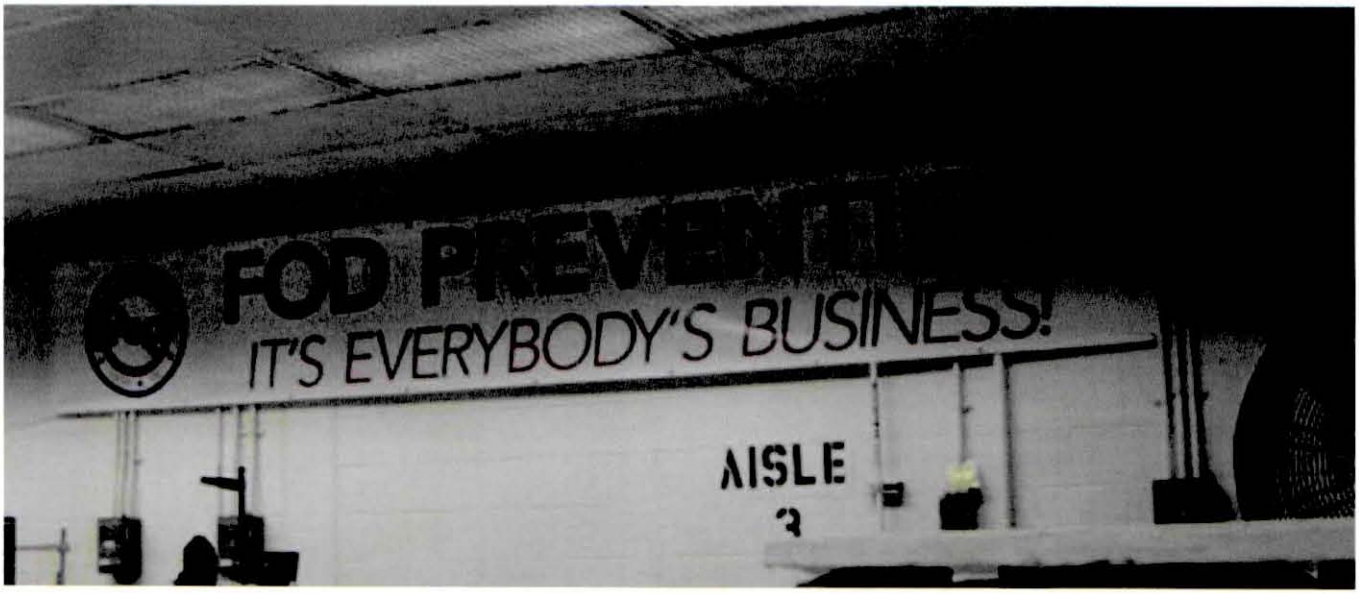
- 5S Workplaces:
  - Sorting
  - Straightening
  - Shining
  - Standardizing
  - Sustaining



Credit: Beyondlean.wordpress.com

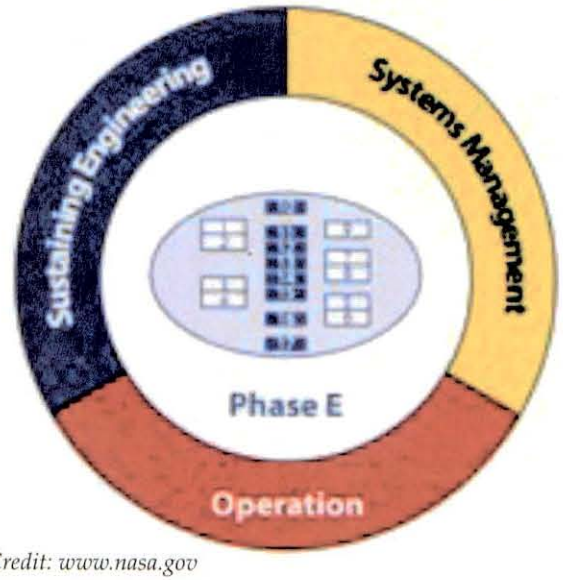
- Many offices, labs and contractors use this already

Places we saw LEAN



OPERATION

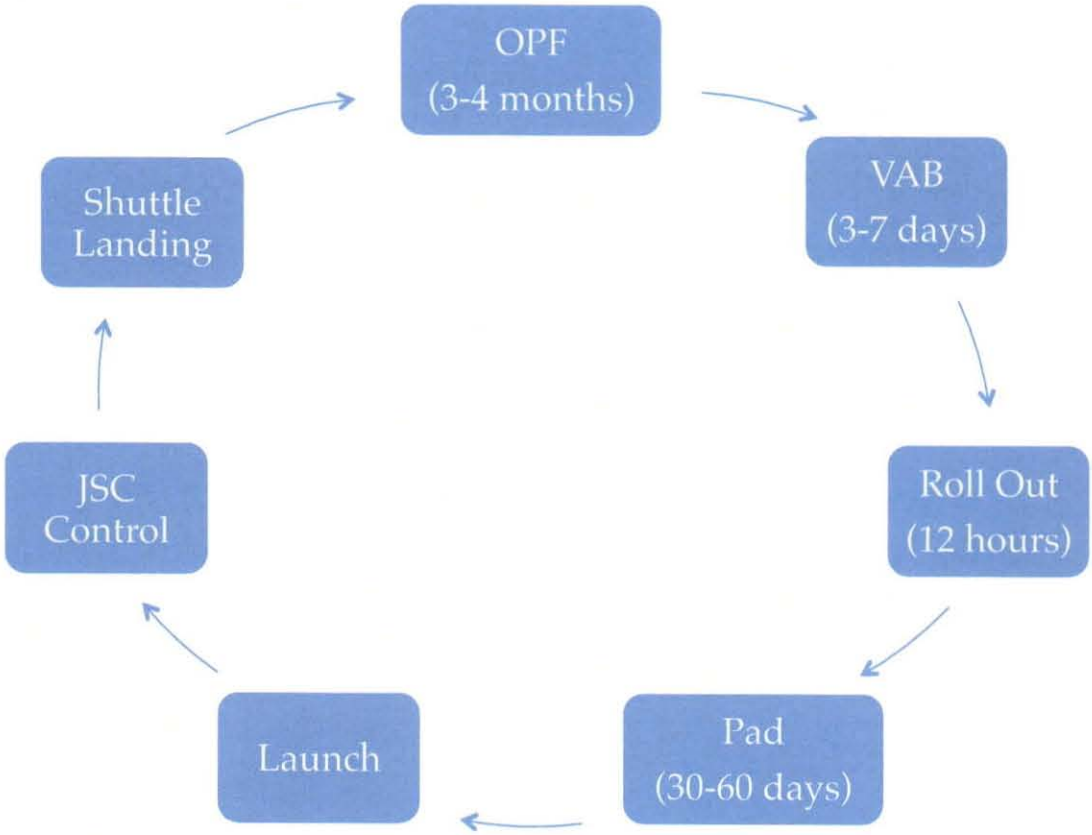
Shuttle Operations and Sustainment



Credit: www.nasa.gov

- Spares and refurbishment for reusable parts
- Orbiter tiles require replacement/ refurbishment
- SRBs require cleaning and refueling
- Parachutes require cleaning and repacking

KSC Shuttle Operations

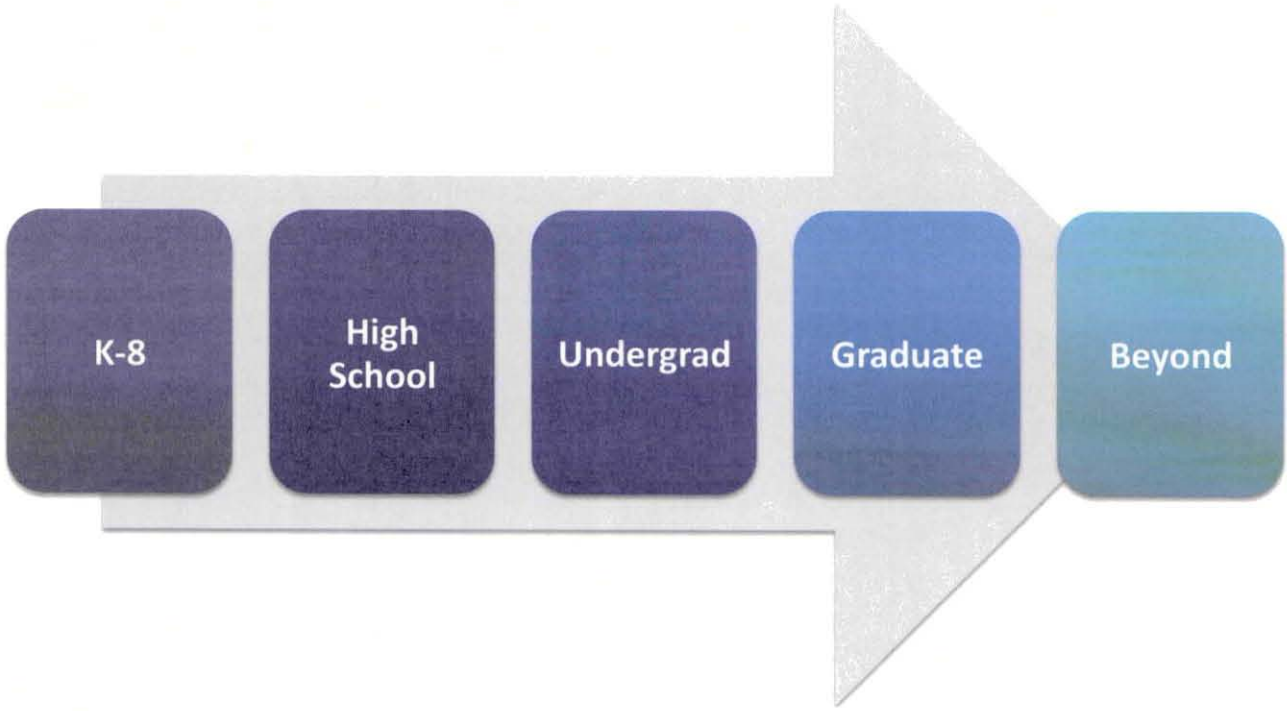


Closeout of the Shuttle Program

- Plan final flights
- Dispose of hazardous materials, determine the future for ground facilities, etc.
- Top to bottom analyses of program elements
- Data/information requires analysis and archiving
- Workforce reduction
- Rehire issues

EDUCATION

Education Programs



Education Programs

- K-8
  - EarthKam
  - Fly your face in space
  - Send your name to Mars
  - Pluto Pals
- High School
  - FIRST Robotics
  - Space Settlement Design Contest
  - MyNASA
  - NASA Facebook
- Undergraduate
  - Internships (SURF, Space Grant, etc)
  - Future of Flight competition
  - Lunabotics Mining Competition
  - NASA Academy
- Graduate
  - Graduate Student Research Program
  - UARC STI Graduate Student Summer Internship Project
  - PhD mentors

Beyond

- NASA TV
- Launches
- Astronaut Tweets
- NASA iPod applications

Credit: www.nasa.gov

PRESS

Press

- NASA TV
- Mobile satellite uplink trucks
- Manned flights have most attention
- Historically has not approached networks
  - Missed opportunity to educate public
- Challenges in advertising

Credit: Wunderground.com

Press

- Convey NASA to public
- Translate policy and policy implications
- Promotions beyond Florida area
  - Extend NASA speakers program
  - Creative marketing

Credit: www.nasa.gov

NASA Spinoffs

- Light-emitting diodes (LEDs)
- Infrared ear thermometers
- Ventricular assist device
- Artificial limbs
- Transportation
- Aircraft anti-icing systems
- Highway safety
- Improved radial tires
- Chemical detection
- Public safety
- Video enhancing and analysis systems
- Fire-resistant reinforcement
- Firefighting equipment
- Consumer, home, and recreation
- Tempur foam
- Enriched baby food
- Portable cordless vacuums
- Environmental and agricultural resources
- Water purification
- Solar energy
- Pollution remediation
- Computer technology
- Structural analysis software
- Remotely controlled ovens
- Industrial productivity
- Powdered lubricants
- Improved mine safety
- Food safety
- Kidney dialysis machines
- CAT Scanner
- Cardiovascular conditioner machine
- Cook/chill concept
- Athletic shoe design
- Athletic shoe manufacture
- Freeze-dried food
- Insulation (mylar)
- Water purification technology
- Surface enhancement coatings
- Digital signal-processing for CAT scans & MRIs
- Vacuum metallizing techniques
- Cordless power tools
- Cool suits


Credit: Wikipedia

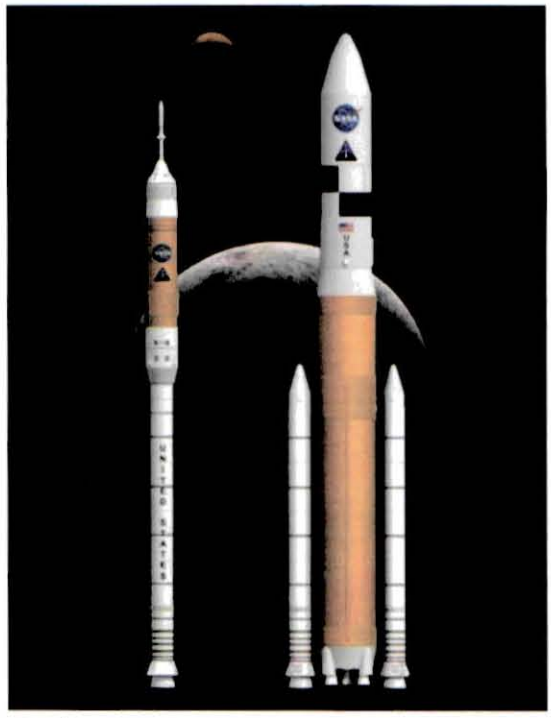

Credit: Wikipedia


Credit: About.com

FUTURE

Future of NASA

- Space Shuttle retirement
- Constellation
- ISS requires resupply and maintenance: Foreign and commercial options
  - Soyuz: $56 million per seat
  - SpaceX
  - Orbital Sciences



Credit: www.nasa.gov

COTS

- Use commercial industry to service the ISS in a more profitable and efficient manner
- Cargo and crew transportation capabilities
- Funding once reach milestones (performance objectives) with ISS
- Access to all NASA archives, experts, and experience

Orbital Sciences

- 150 major space and rocket missions in 7 years
- Focus on satellites and space systems, launch vehicles, and advanced space programs
- Clear market focus, product line breadth, technical excellence and cost efficiency
- Moderate use of contractors

Taurus II & Cygnus

- Taurus II is medium class launch vehicle
- Cygnus is advanced maneuvering spacecraft
- COTS demo in the second half of 2011
- 8 pressurized cargo missions from late 2011 or early 2012 through 2015
- $40-45 million

Credit: www.nasa.gov

SpaceX

- Reduce the cost and increase the reliability of space access by a factor of ten
- Simplicity, low cost, and reliability can go hand in hand
- Eliminate traditional layers of management internally and sub-contractors externally
- Design for reuse
- Limited use of contractors

SPACEX

Falcon 9 & Dragon

- Falcon 9- launch vehicle
- Dragon- pressurized capsule with unpressurized trunk
- COTS Demo 1 success
- Next steps: integrated launch abort system and crew accommodations
- COTS Demo 2 and 3
- $50 million

Credit: www.nasa.gov

SE in the Commercial Industry

- Contracts and the make/buy dilemma (capability and budget considerations)
- Budget, risk, and performance optimization
- CDIO execution must emphasize the connection between design and operation
- Few failures to learn from thus far

NASA and Commercial Industry

- Man-rating (i.e.: LETF)
- Facilities available with the end of the Shuttle program
  - space vehicle processing and launch facilities
  - off-line processing facilities
  - payload processing facilities
- Advantages and disadvantages of using NASA facilities

Acknowledgements

- Helen Kane
- Raji Patel
- Dr. Jeff Hoffman
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- Everyone who spent time with us, showed us around, regaled us with stories from Shuttle and Apollo, entertained us, and gave us design and career advice